Dividing (1) by (2)

$$\frac{E_1}{E_2} = \frac{B_1(S + R_1 + R_2) + R_1 S}{(r + B_2)(S + R_1 + R_2) + R_2 S} \qquad (3)$$

which is the formula required.

NO. XV. — ON A NEW METHOD OF MEASURING THE RESISTANCE OF A GALVANIC BATTERY.

By B. O. Peirce, Jr.

Presented, March 14, 1877.

Of the many known methods of measuring the resistance of a galvanic battery, only two, those of Mance and Thomson, are found to give accurate results. A third method, which seems to work well in practice, is this: —

A known resistance (r), a galvanometer of known resistance (G), and the battery whose resistance is to be measured, are joined up in a simple circuit. The battery is shunted, and the deflection of the galvanometer needle is noted. This shunt is now removed, and the galvanometer is shunted, so that it gives the same deflection as before. A knowledge of the ratio of the resistances of the shunts gives the resistance of the battery by means of a simple formula. Let E be the electromotive force of the battery, and B its resistance, and let S and σ be the resistances of the shunts. In the expressions that follow, C_G, C_S, and C_σ denote currents passing through the galvanometer and the two shunts respectively.

When the battery is shunted, the whole current in the circuit is

$$C = \frac{E}{\frac{1}{\frac{1}{S} + \frac{1}{r + G}} + B} = \frac{E(S + r + G)}{S(r + G) + B(S + r + G)} \qquad (1)$$

Kirchoff's Laws give

$$C = C_G + C_S \quad \text{and} \quad C_S \,.\, S = C_G(r + G)$$

therefore

$$C = C_G \frac{(S + r + G)}{S} \qquad (2)$$

Equating the second members of (1) and (2)

$$ES = C_G \left\{ S(r + G) + B(S + r + G) \right\} \qquad (3)$$

When the battery shunt is removed, and a shunt put across the terminals of the galvanometer, the whole current traversing the circuit is

$$C' = \frac{E}{\frac{1}{\frac{1}{\sigma} + \frac{1}{G}} + r + B} = \frac{E(\sigma + G)}{G\sigma + (r + B)\,(G + \sigma)} \qquad (4)$$

Kirchoff's Laws give

$$C' = C_G + C_\sigma \quad \text{and} \quad C_\sigma \,.\, \sigma = C_G \,.\, G$$

therefore

$$C' = C_G \left(\frac{\sigma + G}{\sigma} \right) \qquad (5)$$

Equating the second members of (4) and (5)

$$E\sigma = C_G \left\{ G\sigma + (r + B)\,(G + \sigma) \right\} \qquad (6)$$

Dividing (3) by (6) and cancelling, we have, since the current passing through the galvanometer is the same in both cases,

$$[G\sigma + (r + B)\,(G + \sigma)]S = [S(r + G) + B(S + r + G)]\sigma$$

or if

$$\delta = \frac{\sigma}{S}$$

$$B = \frac{rG}{(r + G)\delta - G}.$$

In practice, the terminals of r are connected to the galvanometer and to the battery respectively by binding-screws with three wire holes in each. One terminal of a Wheatstone's Rheostat is permanently fastened to one pole of the battery, and the other terminal is connected, first with the binding-screw on one side of r, and then with that on the other side. The handle of the Rheostat is to be turned until the galvanometer needle gives the same deflection in the second

case as in the first, and the ratio of the lengths of the shunt are taken to represent the ratio of their resistances.

With a piece of uncovered copper wire, not more than two metres long, and a resistance r equal to only twenty-four one hundredths of an ohm, I have obtained results which are quite as good as those obtained with a box of resistance coil, using Thomson's method.

r should be a small resistance of not over five ohms for a long-coil galvanometer, and not over three ohms for a short-coil galvanometer. This method offers some advantages over that of Thomson, but it is not generally as good as the method due to Mance.